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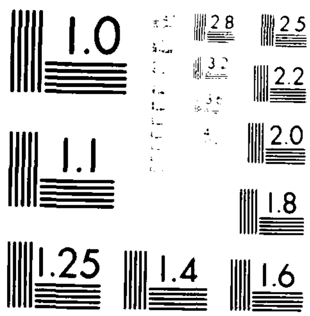

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US Army Corps
of Engineers

APR 1984

Drought Contingency Plan

Otter Brook Lake, Keene, New Hampshire

AD-A143 758

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It has been determined that a portion of the existing storage at Otter Brook could be used for water storage. The water could temporarily be stored to an elevation of 708 ft. Project would provide approximately 1,300 acre-feet (425 million gallons) of storage for water. The water is basically good quality but has high levels of color and metals which will have to be removed for public water supply use. Suitable for fire-fighting, irrigation or some industrial process.

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CONNECTICUT RIVER BASIN
ASHUELOT RIVER WATERSHED

DROUGHT CONTINGENCY PLAN
OTTER BROOK LAKE
KEENE, NEW HAMPSHIRE

APRIL 1984

NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

DROUGHT CONTINGENCY PLAN
OTTER BROOK LAKE

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF PLATES

DROUGHT CONTINGENCY PLAN
OTTER BROOK LAKE

1. PURPOSE AND SCOPE

The purpose of this study and report was to develop and set forth a drought contingency plan of operation for Otter Brook Lake that would be responsive to public needs during drought periods and identify possible modifications to project regulation within current administrative and legislative constraints. This evaluation was based on preliminary studies utilizing readily available information. The scope of this drought contingency plan includes a description of existing water supply conditions, the possibility of reallocation of reservoir storage within specified limits, water quality evaluation, discussion of impacts on other project purposes, effects on the environment, summary and conclusions.

2. AUTHORIZATION

The authority for the preparation of drought contingency plans is contained in ER 1110-2-1941 which provides that water control managers will continually review, and, when appropriate, adjust water control plans in response to changing public needs. Drought contingency plans will be developed on a regional, basinwide and project basis as an integral part of water control management activities.

3. PROJECT AUTHORIZATION CONDITIONS

Otter Brook Lake was authorized by the Flood Control Act approved 3 September 1954 (Public Law 780, 83rd Congress) which modified the act of 1936 as amended and supplemented to provide for the flood control reservoir on the Otter Brook at South Keene, New Hampshire. The project is included in the Flood Control Compact adopted by the States of Connecticut, Massachusetts, Vermont and New Hampshire and approved 6 June 1963.

4. PROJECT DESCRIPTION

Otter Brook Lake, completed in 1958, is located in the city of Keene, New Hampshire, on Otter Brook, a tributary of the Ashuelot River. A map of the Connecticut River basin is shown on plate 1.

The lake contains storage for recreation and flood control. The recreation pool at elevation 703 feet NGVD (20-foot stage) contains 870 acre-feet (283 million gallons) equal to 0.35 inch of runoff. The flood control storage contains 17,450 acre-feet (5.7 billion gallons) equivalent to 7.0 inches of runoff from the 47 square mile drainage area. An area capacity table is shown on plate 2, and a summary of pertinent data at Otter Brook Lake is contained on plate 3.

Principal components of the project consist of a compacted earth and rock faced dam, outlet works and a concrete chute spillway. The outlet

works include a 6-foot diameter horseshoe-shaped conduit with an invert at elevation 683 feet NGVD. Flow through the outlet is controlled by three 2'-6" by 4'-6" hydraulically operated vertical slide gates. A permanent concrete weir containing five stoplog openings is located upstream of the center gate and maintains a permanent pool at about elevation 703 feet NGVD.

5. PRESENT OPERATING REGULATIONS

a. Normal Periods. A permanent pool is maintained at a age of about 20 feet by the control weir and stoplogs located immediatel stream of the center gate. The gate setting, 0-3'-0, restricts discharges so that significant reservoir releases do not occur during unexpected events. During the winter, the center gate is closed and submerged to prevent freezing and the pool is regulated by one of the side gates.

b. Flood Periods. The Otter Brook project is operated in concert with other projects in the basin to reduce downstream flooding on Otter Brook, the Branch, the Ashuelot and Connecticut Rivers. Operations for floods may be considered in three phases: phase I - appraisal of storm and river conditions during the development of a flood, phase II - flow regulation and storage of flood runoff at the reservoir and phase III - emptying the reservoir during recession of the flood. The regulation procedures are detailed in the Master Water Control Manual for the Connecticut River basin.

c. Regulating Constraints

(1) Minimum Releases. A minimum release of about 10 cubic feet per second (cfs) or 6.5 million gallons per day (mgd) is maintained during periods of flood regulation in order to sustain downstream fish life.

(2) Maximum Releases. The maximum nondamaging discharge capacity of the channel immediately downstream from Otter Brook Lake is about 650 cfs. Releases up to or near this rate can be expected whenever reservoir inflows exceed this value, and meteorological and hydrologic conditions permit.

6. MONITORING OF HYDROLOGIC CONDITIONS

The Reservoir Control Center directs the reservoir regulation activities at 28 New England Division flood control dams, and continually monitors rainfall, snow cover and runoff conditions throughout the region. When any of these hydrologic parameters have been well below normal for several months and it appears that possible drought conditions might develop, the Corps Emergency Operations Center (EOC) will be so informed. The EOC will then initiate discussions with the respective Federal and State agencies and other in-house Corps elements to review possible drought concerns and future Corps actions.

7. DESCRIPTION OF EXISTING WATER SUPPLY CONDITIONS

a. General. The area of concern is the extreme southwestern portion of New Hampshire, lying entirely within Cheshire County. Table 1 contains information about public water suppliers in the area based on information provided by the New Hampshire Water Supply and Pollution Control Commission. The information was taken from the Facilities and Policy Summary published in 1981. Of the 13 communities in the study area, portions of seven are served by a public water supply system. No data is available for those communities dependent on private individual supplies.

b. Water Supply Systems. The primary objective of this analysis was to accumulate available data regarding water supply systems in the vicinity of Otter Brook Lake which could benefit from storage at the project, and to present the data in a manner portraying existing water supply conditions. Projections of future demands were not developed because this study addresses only modifications in the operational procedure at Otter Brook Lake in order to provide storage for water supply purposes when emergency drought conditions exist, and not to meet normal water supply demands at some future date.

c. Southwestern New Hampshire Water Suppliers. As noted in table 1, the data given for each water supplier included: community served, estimated population served by the system, source of supply (ground or surface water), average and maximum day demands for 1980 and the estimated safe yield of each source where available. An analysis of the adequacy of existing sources during drought conditions has not been performed. The information has been accumulated to present a summary of the existing water supply conditions for the southwestern New Hampshire area.

d. Population Projections. Population projections for communities in southwestern New Hampshire are given in table 2 to show population trends for each community potentially affected by a prolonged dry period. The projections were provided by the New Hampshire Office of State Planning which developed population projections statewide from criteria the Corps of Engineers used for projecting populations in the southeastern New Hampshire Water Resources Study. This information indicates areas of potential future growth in the southwestern New Hampshire area.

8. POTENTIAL FOR WATER SUPPLY REALLOCATION

a. General. There are several authorities that provide for the use of reservoir storage for water supply at Corps of Engineers projects. They vary from the provision of water supply storage as a major purpose in new projects to the discretionary authority to provide emergency supplies to local communities in need. In addition, guidance contained in ER 1110-2-1941

TABLE 1
PUBLIC WATER SUPPLIERS - SOUTHWESTERN NEW HAMPSHIRE

COMPANY OR AGENCY	TOWN SERVED	EST. POPULATION SERVED - 1981	SOURCE OF SUPPLY SW/GW	1981 DEMAND AVG. DAY (MGD)	MAX. DAY (MGD)	SUPPLY SOURCE	SAFE YIELD (MGD)
•	Chesterfield		No Public Water Supply				
	Gilsum		No Public Water Supply				
Hinsdale Water & Sewer Works	Hinsdale	3,000	GW	.667	.840	GP Well (Two)	0.60
Keene Water Works	Keene	25,000	GW/SW	3.314	5.117	Babbidge Dam	2.30
						GP #1 West	0.75
						GP #2 Court St.	1.00
						GP #3 Court St.	1.00
						GP #4 Court St.	1.00
Marlboro Water Works	Marlboro	348	GW	No Meter		GP #1 School St. (Aux)	--
						GP #2 Fitch Court	--
	Richmond		No Public Water Supply				
	Roxbury	(60 Connections)				Keene Water Works	
	Sullivan		No Public Water Supply				
	Surry		No Public Water Supply				
North Swanzey Water Dept.	Swanzey	(380 Connections)				Keene Water Works	
Troy Water Works	Troy	1,200	GW/SW	.420	.480	Fassett Brook	--
						BR Well	--
	Westmoreland		No Public Water Supply				
Winchester Water Dept.	Winchester	2,500	GW	.537	.600	GP #1 Keene Rd.	0.32
						GP #2 Keene Rd.	0.46
						GP #3 Richmond Rd.	1.15

TABLE 2
POPULATION PROJECTIONS - SOUTHWESTERN NEW HAMPSHIRE

TOWN	Actual 1980	1985	1990	1995	2000	Percent Change
Chesterfield	2,559	2,939	3,372	3,823	4,169	62.9
Gilsum	643	706	750	787	813	26.4
Hinsdale	3,632	3,584	3,736	3,789	3,827	5.4
Keene	21,385	21,782	21,901	22,088	22,400	4.7
Marlboro	1,850	1,963	2,054	2,130	2,188	18.3
Richmond	516	598	690	792	871	68.8
Roxbury	193	208	224	238	248	28.5
Sullivan	585	678	782	898	988	68.9
Surry	662	767	885	1,016	1,118	68.9
Swanzey	5,179	5,712	6,293	6,916	7,395	42.8
Troy	2,128	2,320	2,526	2,738	2,899	36.2
Westmoreland	1,448	1,675	1,899	2,156	2,372	63.8
Winchester	3,440	3,612	3,793	3,965	4,084	18.7
	44,220	46,644	48,905	51,336	53,372	20.7

directs field offices to determine the short-term water supply capability of existing Corps reservoirs that would be functional under existing authorities. Congressional authorization is not required to add municipal and industrial water supply if the related revisions in regulation would not significantly affect operation of the project for the originally authorized purposes.

b. Drought Contingency Storage. It has been determined that a portion of the existing flood control storage at Otter Brook Lake could be utilized for emergency drought contingency storage without having an adverse impact on the project's flood control function. Maximum storage could be made available to a pool elevation of about 715 feet NGVD (32-foot stage). This represents a total volume of about 2,040 acre-feet, equivalent to 665 million gallons or about 11 percent of the total reservoir storage. This volume is comprised of 870 acre-feet of permanent storage, and 1,170 acre-feet of flood control storage. The 1,170 acre-feet represent an infringement of about 0.50 inch of runoff on the flood control storage. However, an evaluation of the effects of this proposed level has revealed some significant adverse impacts on the aquatic and terrestrial environments and on several recreational aspects. Therefore, consideration is given to limiting drought storage to a pool elevation of 708 feet (25-foot stage). This level represents a total volume of 1,300 acre-feet, equivalent to 425 million gallons.

Based on an all-season low flow duration analysis using 23 years of flow records for the gaging station on Otter Brook near Keene, New Hampshire, it was determined that during a 10-year frequency drought the volume of runoff could: (a) fill the reservoir from elevation 703 to 708 feet NGVD in a 60-day period provided no releases were made from the dam, or (b) fill the reservoir to elevation 708 in a 150-day period if a continuous release of about 4.7 cfs or 3 mgd (0.10 cfs/sq. mi. csm) were maintained. However, the reservoir could be filled to elevation 708 in about a one week period in May while continuously releasing about 10 cfs or 6.5 mgd. The water stored could be drawn directly from the reservoir or released downstream during or prior to the completion of the filling period for municipal supply with proper treatment. Drought contingency storage versus flow duration at Otter Brook Lake is shown graphically on plate 4.

c. Effects of Regulated Flows. The curtailment of flows from Otter Brook Lake during the drought emergency could adversely impact the flowage rights of downstream riparian users. At this time, however, it is not possible to review all of the various drought emergency situations that could occur, nor is it within the scope of this report to identify all those with water rights. It is important to note that when a specific drought emergency situation does occur, the legal implications would have to be weighed.

9. WATER QUALITY EVALUATION

a. Water Quality Classification. The entire length of Otter and its tributaries in New Hampshire are rated class B by the New shire Water Supply and Pollution Control Commission. Class B wat high aesthetic value and are acceptable for swimming and other re fish habitat, and after adequate treatment, for use as water supp Otter Brook Lake is further classified as a warm water fishery.

Technical requirements for class B waters include no objectio physical characteristics, a minimum dissolved oxygen (DO) concent 75 percent saturation or 6 mg/l, pH in the range of 6.5 to 8.0 st units except due to natural conditions, no more than 240 coliform per 100 milliliters, and a maximum turbidity level of 10 JTU's.

b. Existing Water Quality. The waters of Otter Brook Lake a quality, usually meeting or exceeding the requirements of their N shire class B designation. DO levels in Otter Brook and Otter Br are consistently high. However, low and even anaerobic condition in the deepest parts of the lake during summer stratification. T currence of anaerobic conditions is minimized by opening one of t a small amount. This low level release does not violate state sta because it is mixed with the well-aerated surface waters flowing weir. Other water quality measurements indicating good condition low levels of coliform bacteria, turbidity, and dissolved solids, to moderate hardness.

While Otter Brook Lake's water quality is good, certain measu indicate some treatment will be required for water supply usage. precipitation and natural soil conditions contribute to low pH le frequently violate state criteria. In a public water supply low are not a health problem but may cause corrosion problems. Water conditions for which there are no state standards but are of poss concern in a public water supply include high iron, mercury, and c centrations. High iron levels are rare. Iron is not a health ha water, but high levels of iron can cause taste and laundry-staini Findings of detectable concentrations of mercury are very rare, b slightly elevated readings have been recorded. These are believe to natural watershed conditions and not a real cause for concern. concentrations, probably due to natural watershed conditions, are moderate to high. While not a health hazard, highly colored wate unappealing to water consumers. High color, iron, and mercury le be reduced by standard treatment processes.

Otter Brook is a borderline mesotrophic-oligotrophic impoundm hibiting weak to moderate thermal density induced stratification

summer. Temperature differences of 38^{o} Fahrenheit are possible between the surface and bottom of the lake. The lake has a hydraulic residence time (the lake volume divided by the outflow) of 1 to 3 weeks under normal summer flow conditions. Under minimum flow conditions the lake approaches complete stagnation.

c. Water Quality Requirements for Drought Storage. There are two requirements to be met. The waters must meet state standards for surface waters and must be of a quality suitable for the water supply user. A water which meets class B standards in New Hampshire is usable for public water supply with standard treatment processes. The water quality required for industrial water supply depends on the industrial process involved. The water at Otter Brook Lake would always be of a quality suitable for fire-fighting or irrigation.

d. Effects of Drought Storage. Increasing the size of the pool at Otter Brook Lake for drought storage will affect existing water quality in the lake. With the proposed depth increase of 5 feet above the permanent pool, an additional 17 acres of land would be flooded. The decay or organic material on the land may increase the extent and duration of anaerobic conditions in the lake. Present hydraulic residence time during normal summer flow conditions would increase from 1 to 3 weeks to 2 to 5 weeks; under minimum flows the lake would become stagnant. This could lead to increases in levels of color. It is also possible that high concentrations of iron and mercury could occur more frequently. These substances could be removed prior to the water's use for public supply if needed. The trophic status of the lake is not likely to change and the water quality for recreation and warm water fishery will not be affected.

Raising the pool five feet would also cause increases in turbidity and sedimentation. The death of the vegetation in the newly inundated areas would loosen the soil and cause increased erosion in these areas when the pool is drawn down. Most of the eroded soil would settle in the lake, but some would be discharged downstream. This increased erosion and sedimentation will not affect the suitability of the water for water supply or recreation, but will affect the aesthetics of the area.

Releases from a deeper reservoir may be cooler. Presently warmer, well aerated surface waters discharge at elevation 703 feet NGVD, 2 feet above the top of the weir. Increasing the depth 5 feet above the permanent pool may mean cooler temperatures and lower DO levels will be discharged downstream. The lower DO levels would probably be raised by the effect of turbulence in the outlet channel. The cooler temperatures are not likely to be enough to have a deleterious effect on the warm water fish population downstream.

e. Water Quality Conclusions. The water at Otter Brook Lake is basically good quality but has high levels of color and metals which will have to be removed before it is suitable for public water supply. Undesirable color and metals can be removed by standard treatment processes. No treatment would be required for the water to be suitable for fire-fighting, irrigation, or some industrial processes. Increasing the pool elevation by 5 feet to provide extra storage would increase levels of color, metals, turbidity, and erosion and sedimentation but would not significantly affect the suitability of the water for water supply or recreation.

10. DISCUSSION OF IMPACTS

a. General. Any action resulting in a temporary change of a reservoir's storage volume will have impacts on other project purposes which must be evaluated before a storage reallocation plan can be implemented. An evaluation has been made of the impacts resulting from drought contingency storage on the flood control purpose of this project. Effects on recreation, sedimentation and the aquatic and terrestrial environments as well as the historic and archaeological resources are discussed in the following paragraphs. Because of the minimal level of effort afforded this study, certain environmental concerns may require further consideration prior to project implementation. These are identified in the appropriate environmental sections, with estimates of the amount of time needed for such further assessments.

b. Flood Control. A review of the regulation procedures at Otter Brook Lake was undertaken to determine the volume of water that could be made available for drought contingency purposes. The water would be temporarily stored by utilizing existing flood control storage. It is recognized that major floods occur in every season of the year, thus any use of flood control storage would be continually monitored to insure there would be no adverse impacts on downstream flood protection.

At Otter Brook Lake, the proposed pool elevation for drought contingency storage has been estimated to be elevation 708 feet (25-foot stage) representing an infringement on the flood control storage of about 0.25 inch of runoff from the upstream 47-square mile drainage area.

Based on a 10-year low flow event, the anticipated rate of pool level rise to the 708 elevation would be about 0.03 foot per day over a 150-day period beginning in June. This condition assumes a flow of about 4.7 cfs (0.1 csm) would be released downstream for the duration of the drought. Storage would probably take place during the months of May, June, July, and August and would be drawn as needed in the following months. The

storage may be held for a period of one month or longer at the 708-foot elevation before withdrawal.

c. Recreation. The beach area would be submerged when the reservoir level reaches a stage of 25 feet (elevation 708). The grass play area between the parking lot and the beach would be flooded at stage 27 or elevation 710. Shoreline trees in the southern end of the reservoir would start to be inundated at a stage of 27 feet. Any vegetation that is flooded during the summer months for the duration of the proposed drought storage period would not survive.

d. Project Operations. Drought contingency storage levels above elevation 704 feet (stage of 21 feet) must be controlled by means of gate regulation because the top elevation of the concrete weir with stoplogs is 704 feet. It will be the responsibility of the requestor to pay the cost of regulating for additional storage, and for any cleanup activities associated with maintaining the added drought storage.

e. Effect on the Aquatic Ecosystem. The aquatic environment of the project area is located along Otter Brook and Ferry Brook in the Ashuelot River basin. The waters of the Otter Brook and its tributaries upstream from Otter Brook Lake are rated class B: of high aesthetic value, acceptable for swimming and other recreation, fish habitat, and after adequate treatment, for use as water supplies.

The lower half of the permanent pool does not provide adequate fishery habitat. The upper half provides excellent fishery habitat. Until recently, the upper half of the pool supported a viable warm water fishery; however, in the past five years an unbalance occurred in the age and size class distribution of pickerel, with larger, older fish predominating. This led to predation of the existing bass fishery, reducing their numbers to the point where action was necessary. Following a complete limnological survey in the summer of 1982, it was determined that the bass fishery could be reestablished at little or no cost. In September and October 1983, the reservoir was drawn down, and as much as possible of the existing fish population destroyed. In May 1984, the New Hampshire Fish and Game Department will be stocking the refilled pond with 200-300 largemouth bass of breeding age. Fishing will be banned for two years to allow the new population to become established.

Otter Brook itself is stocked with trout for put-and-take fishing at approximately the upstream boundary of the project, servicing about 3,500 feet of fishable stream. This area is heavily utilized. Ferry Brook, which feeds into the permanent pool, supports a naturally reproducing salmonid population and, in 1984, is planned for modification of the

riffle-pool configuration to enhance the fishery. Currently it is not heavily utilized. Downstream of the dam is primarily a put-and-take trout fishery.

Aquatic plants are common in the shallows in the upper third of the permanent pool, including pondweed, duckweed, pickerelweed and waterlilies. There is a wetland located about 100 yards north of the northern limit of the present pool, about 6 acres in extent, containing primarily cattails. Another wetland area runs nearly the full lower half of Ferry Brook within the project boundaries, and is about 15 acres in extent. This is a mature red maple wetland with scattered white pines. A third wetland area, about one-quarter acre in extent on the eastern side of the pool, and very close to it, is a typical northern bog community where sundews have been found. Plate 5 shows a map of the reservoir area.

An increase in the impoundment for the proposed contingency storage would temporarily raise the water level by approximately 5 feet during the late spring and summer and throughout the storage period. This would temporarily inundate about 20 acres of project lands including parts of Otter Brook and Ferry Brook to the north of the present pool. The 5-foot rise would probably have a negative impact on the wetland areas, and assessment of this impact should be made prior to project implementation requiring a few days effort. Inundation of the steeper east and west shorelines would lead to stress and probably loss of inundated trees resulting in shoreline erosion and increased turbidity and other effects on the aquatic ecosystem. The newly established bass fishery would be expected to spawn in mid to late April with fry emerging from mid-May to mid-June. With filling of the pool in summer, the effects would not be as great as with filling in May, which could seriously interfere with the fishery. Effects on the bass fishery may need further consideration, requiring a few days effort prior to implementation. Little or no effect on the trout fishery in Otter and Ferry Brooks would be expected with development of the drought contingency pool, as the majority of the fish stay upstream of the projected impact area. With stocking mostly in March and April, most of the fishing downstream of the dam takes place before the proposed summertime drought storage period. If storage were to be developed in May, significant impacts could be anticipated and impacts would be required prior to drought contingency plan implementation.

f. Effects on the Terrestrial Environment. The terrestrial environment around the existing pool comprises mainly mixed hardwoods and hemlocks along the eastern and western shores. These shores are steep-sided and cleared to approximately the level of the pool, comprising mostly wetlands and stream, including a mature red maple type wetland, with scatttered white pines as earlier described, to the north of the pool. Also to the north of the pool is the developed recreational beach area and facilities.

Raising the impoundment elevation for short seasonal periods would result in stress and probable loss of the inundated trees and shrubs throughout the area of coverage of the new pool.

g. Effects on Wildlife Wildlife that has been observed in the area includes raccoons, fishery, white-tailed deer, eastern cottontail rabbit, beaver, skunk, and woodchucks. Upland landbird species include woodcocks and ruffed grouse. The area does not support significant usage by waterfowl. Ospreys are occasional visitors to the pool area. Temporary raising of the pool by 5 feet would displace some woodchucks and wetland type wildlife and songbirds, an occupied beaver dam on Ferry Brook and upland species in the upland inundated areas. Effects on the local deer population would be minimal. A winter deer yard is located just outside the area to be inundated, and would not be impacted.

h. Historic and Archaeological Resources. While there are no recorded prehistoric archaeological sites within the Otter Brook project area, a fairly high probability exists for presence of unrecorded sites within the upper portion of the project lands. Examination of historic period maps reveals at least seven farmstead sites and two millsites, most of which date from the 19th century or earlier. Present condition of these sites, or unrecorded historic period sites which may exist, is unknown.

Prior to drought contingency plan implementation, an archaeological survey would be required, involving several weeks duration.

11. SUMMARY AND CONCLUSIONS

It has been determined that a portion of the existing storage at Otter Brook could be utilized for emergency drought purposes without having an adverse impact on the project's flood control effectiveness. The water could be temporarily stored to an elevation of 708 feet. At this level, 5 feet above the permanent pool, it would be possible for the project to provide up to approximately 1,300 acre-feet (425 million gallons) of reservoir storage for drought emergency purposes. An evaluation of the effects of this plan has revealed some adverse impacts on the aquatic and terrestrial environments as well as on several recreational aspects.

The water at Otter Brook is of basically good quality but has high levels of color and metals which will have to be removed before it is suitable for public water supply. Undesirable color and metals can be removed by standard treatment processes. No treatment would be required for the water to be suitable for fire-fighting, irrigation, or some industrial processes.

OTTER BROOK RESERVOIR
AREA AND CAPACITY

DRAINAGE AREA = 47 S.M.

ELEV. M.S.L.	STAGE FEET	AREA ACRES	CAPACITY AC. FT.	CAPACITY INCHES
683	0	11	40	.02
685	2	16	70	.03
687	4	22	110	.04
689	6	27	160	.06
691	8	32	210	.09
693	10	40	290	.11
695	12	47	370	.15
697	14	55	480	.19
699	16	62	590	.24
701	18	70	720	.29
	Recreation Pool = 703			
701	18	70	0	0
703	20	76	150	.06
705	22	83	310	.12
707	24	90	480	.19
709	26	96	670	.26
711	28	103	870	.34
713	30	113	1080	.43
715	32	123	1320	.52
717	34	133	1580	.63
719	36	143	1850	.74
721	38	153	2150	.85
723	40	161	2460	.98
725	42	169	2790	1.11
727	44	177	3140	1.25
729	46	184	3500	1.39
731	48	192	3870	1.54
733	50	197	4260	1.70
735	52	203	4660	1.86
737	54	208	5070	2.02

ELEV. M.S.L.	STAGE FEET	AREA ACRES	CAPACITY AC. FT.	CAPACITY INCHES
739	56	214	5500	2.19
741	58	219	5930	2.36
743	60	226	6370	2.54
745	62	232	6830	2.78
747	64	239	7300	2.91
749	66	245	7790	3.10
751	68	252	8280	3.30
753	70	259	8790	3.51
755	72	266	9280	3.71
757	74	273	9880	3.93
759	76	280	10480	4.15
761	78	288	10980	4.38
763	80	296	11580	4.61
765	82	303	12180	4.85
767	84	311	12780	5.09
769	86	319	13380	5.35
771	88	327	14080	5.57
773	90	336	14680	5.87
775	92	346	15380	6.14
777	94	355	16080	6.42
779	96	365	16780	6.70
781	98	374	17600	7.00
	Crest Elevation = 781			
783	100	383	18280	7.30
785	102	392	19080	7.61
787	104	400	19880	7.93
789	106	409	20680	8.25
791	108	418	21480	8.58
793	110	427	22380	8.92
795	112	435	23180	9.26
797	114	444	24080	9.61

PLATE 2

PERTINENT DATA
OTTER BROOK LAKE

LOCATION	Otter Brook, Keene, New Hampshire
DRAINAGE AREA	47.2 square miles

STORAGE USES
Flood Control
Recreation

RESERVOIR STORAGE

	Elevation msl	Stage feet	Area acres	Acre-Feet	Inches on Drainage Area
Inlet Elevation	683.0	0	12	0	0
Recreation Pool	701	18	70	720	0.3
Spillway Crest	781.0	98.0	374	17,600 (net)	7.0 (net)
Maximum Surcharge	798.3	115.3	452	7,100 (net)	2.9 (net)
Top of Dam	802.0	119.0			

EMBANKMENT FEATURES

Type	*Rolled earth fill, rock slope protection, impervious core*
Length (ft)	1,288
Top Width (ft)	25
Top Elevation (ft,msl)	802.0
Height (ft)	133
Volume (cy)	973,000
Dike	None

SPILLWAY

Location	Right-West Abutment
Type	Uncontrolled, ogee weir, chute spillway
Crest Length (ft)	145
Crest Elevation (ft,msl)	781.0
Surcharge (ft) (1967 criteria)	17.3
Design Head (ft)	13.0
Maximum Discharge Capacity (cfs)	40,000

OUTLET WORKS

Type	Boston Horseshoe
Tunnel, Inside Diameter (ft)	6
Tunnel Length (ft)	589
Service Gate Type	Hydraulic Slide
Service Gate Size	Three 2'6" x 4'6"
Emergency Gate	None
Downstream Channel Capacity (cfs)	600
Maximum Discharge Capacity Spillway Crest (cfs)	1,320
Stilling Basin	*35 ft. long, 25 ft. wide with baffles and 4ft. end sill*

RECREATION WEIR

Type of Structure	Concrete weir w/5 stoplog openings
Location	Upstream of center gate
Weir Length (ft)	31'8"
Stoplog Openings	6' deep by 6'4" wide
Stoplog Sill Stage (ft)	15
Recreation Pool Stage (ft)	18
Manually Operated Gate	6" Diameter Opening

RECREATION POOL

Length (ft)	5,300
Shoreline Length (ft)	12,600
Area (acres)	70

LAND ACQUISITION

Fee Elevation (ft, msl)	755
Fee (acres)	461
Easement Elevation (ft, msl)	797
Easement (acres)	152
Clearing Elevation (ft, msl)	703±

MAXIMUM POOL OF RECORD

Date	April 25, 1969
Stage (ft)	82.6
Percent Full	71

SPILLWAY DESIGN FLOOD

	Original Design 1955	1967 Analysis
Peak Inflow (cfs)	38,000	45,000
Peak Outflow (cfs)	34,500	41,500*
Volume Runoff (acre-ft)	53,000	44,800

* 40,000 Spillway Discharge; 1,500 Conduit Discharge (See Plate E-27)

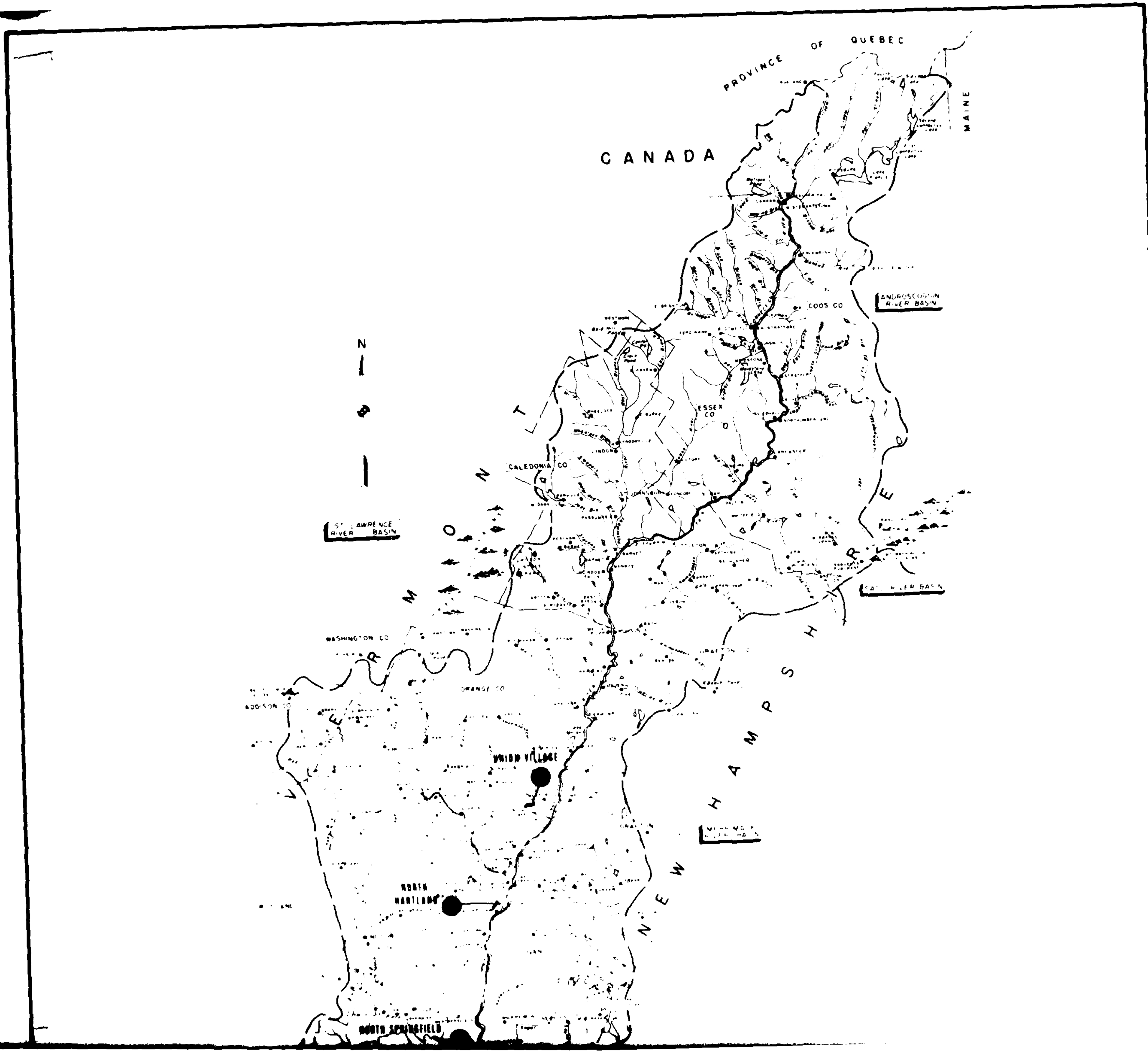
UNIT RUNOFF

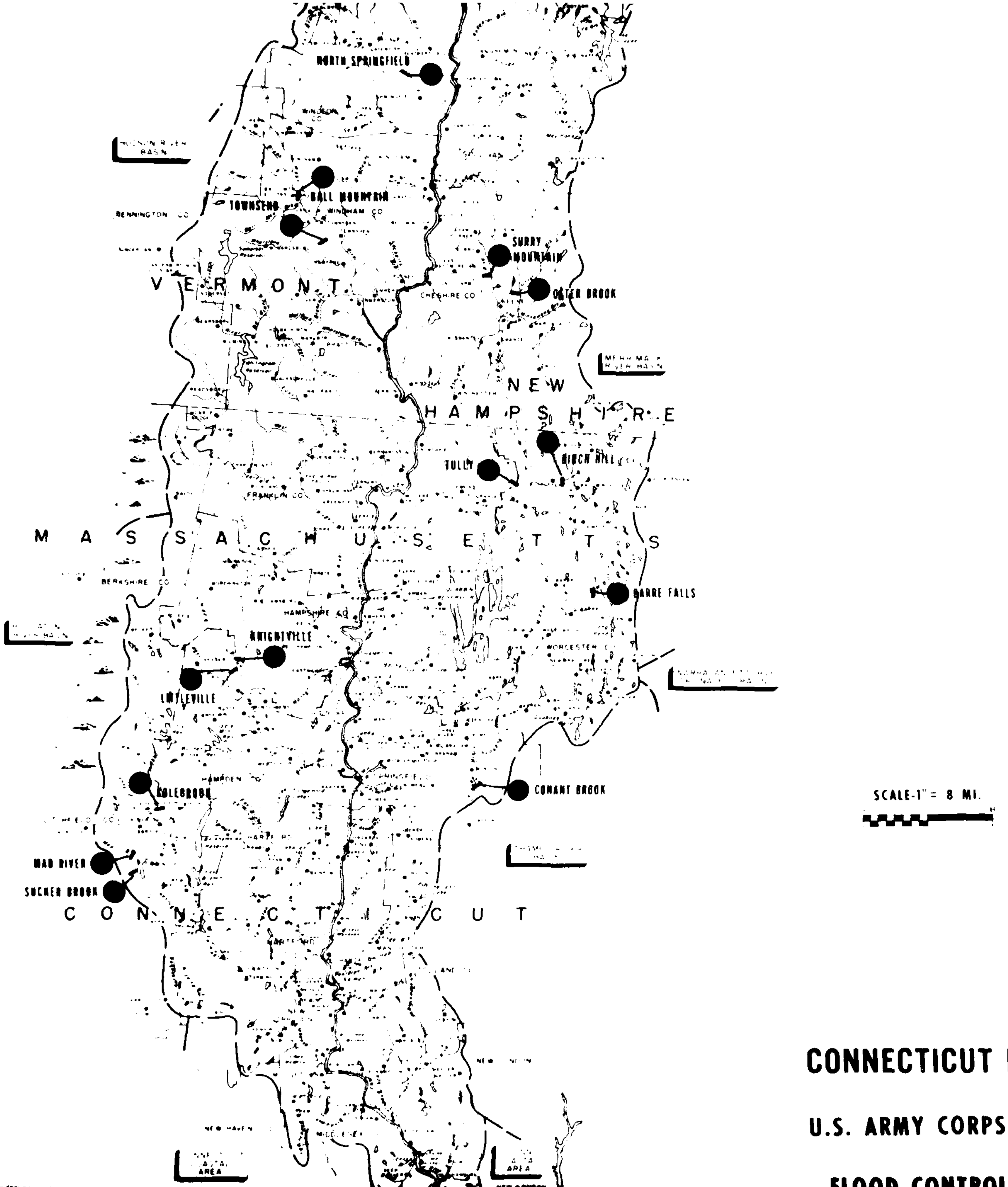
One Inch Runoff (acre-ft)	2,510

OPERATING TIME

Open/Close all Gates	10 min. (No Manual Operation of Gates)

PROJECT COST (thru FY71)	$4,061,000
DATE OF COMPLETION	April 1958
MAINTAINED BY	New England Division, Corps of Engineers Recreation facilities operated and maintained by N.H.

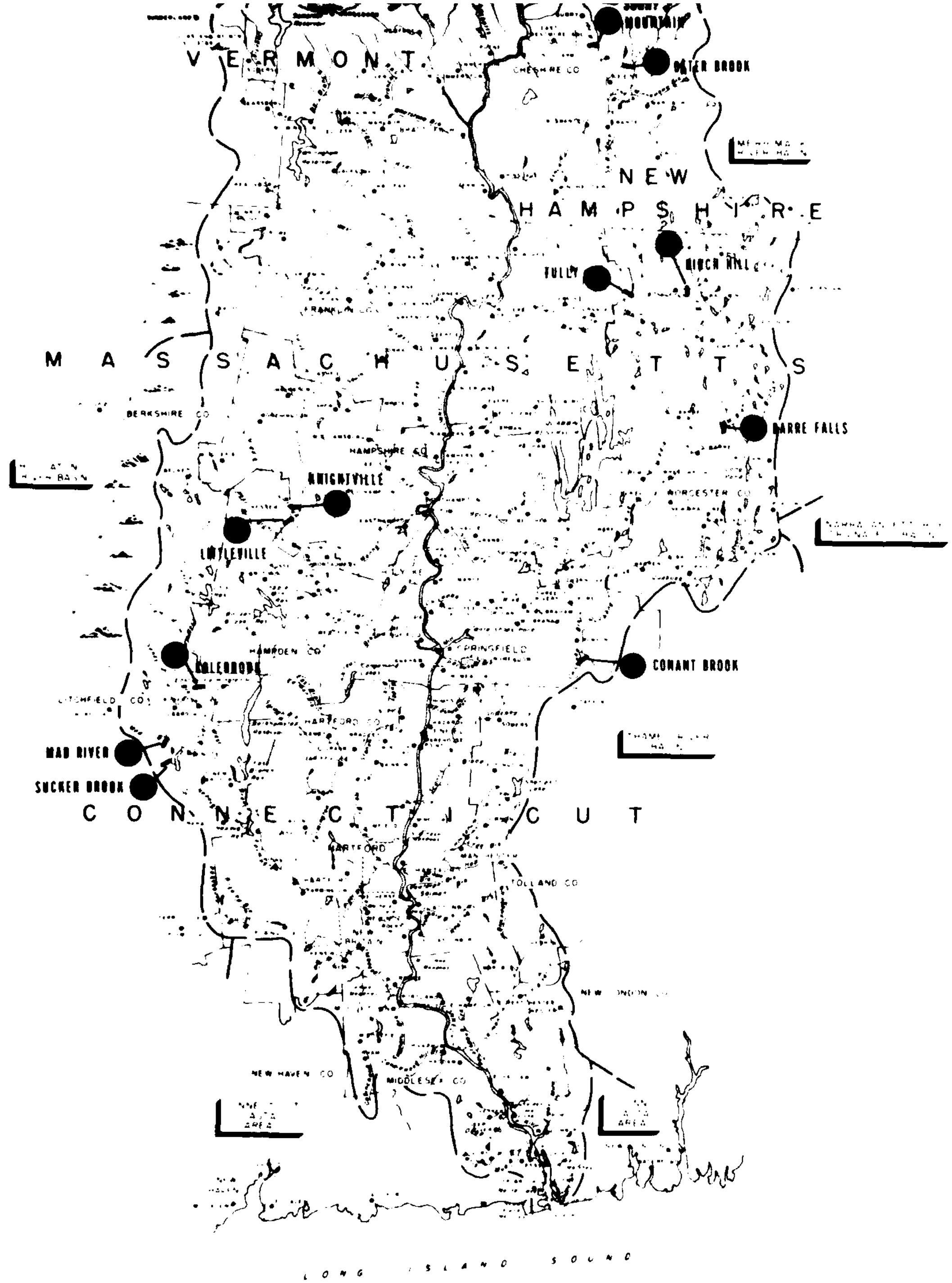

PROVINCE OF QUEBEC
CANADA
MAINE
ANDROSCOGGIN RIVER BASIN
COOS CO
ESSEX CO
CALEDONIA CO
ST. LAWRENCE RIVER BASIN
WASHINGTON CO
ORANGE CO
ADDISON CO
VERMONT
NEW HAMPSHIRE
N
UNION VILLAGE
NORTH HARTLAND
NORTH SPRINGFIELD



CONNECTICUT RIVER BASIN

U.S. ARMY CORPS OF ENGINEERS

FLOOD CONTROL RESERVOIRS



SCALE-1" = 8 MI.

CONNECTICUT RIVER BASIN

U.S. ARMY CORPS OF ENGINEERS

FLOOD CONTROL RESERVOIRS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

JANUARY 1981

PLATE I

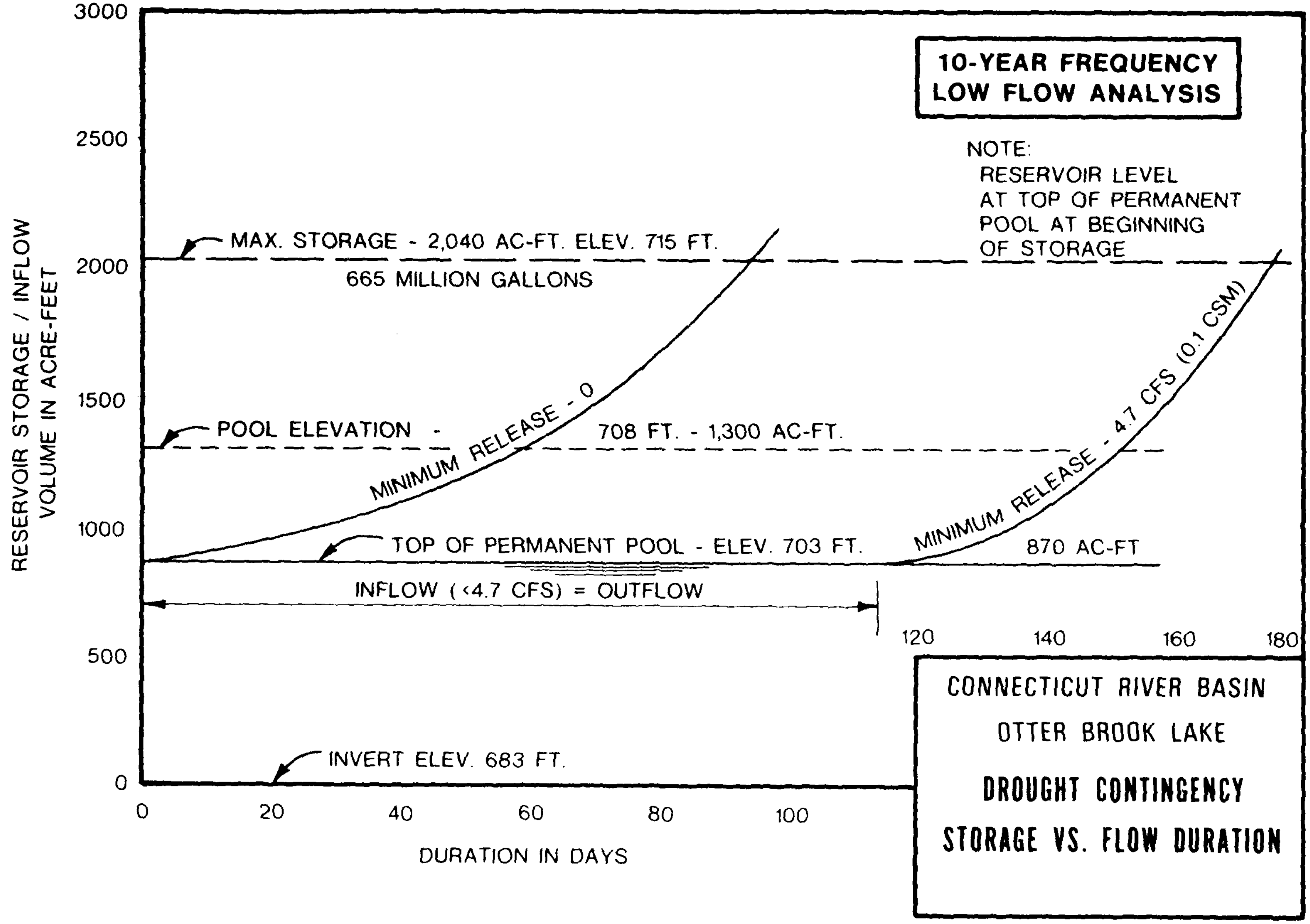
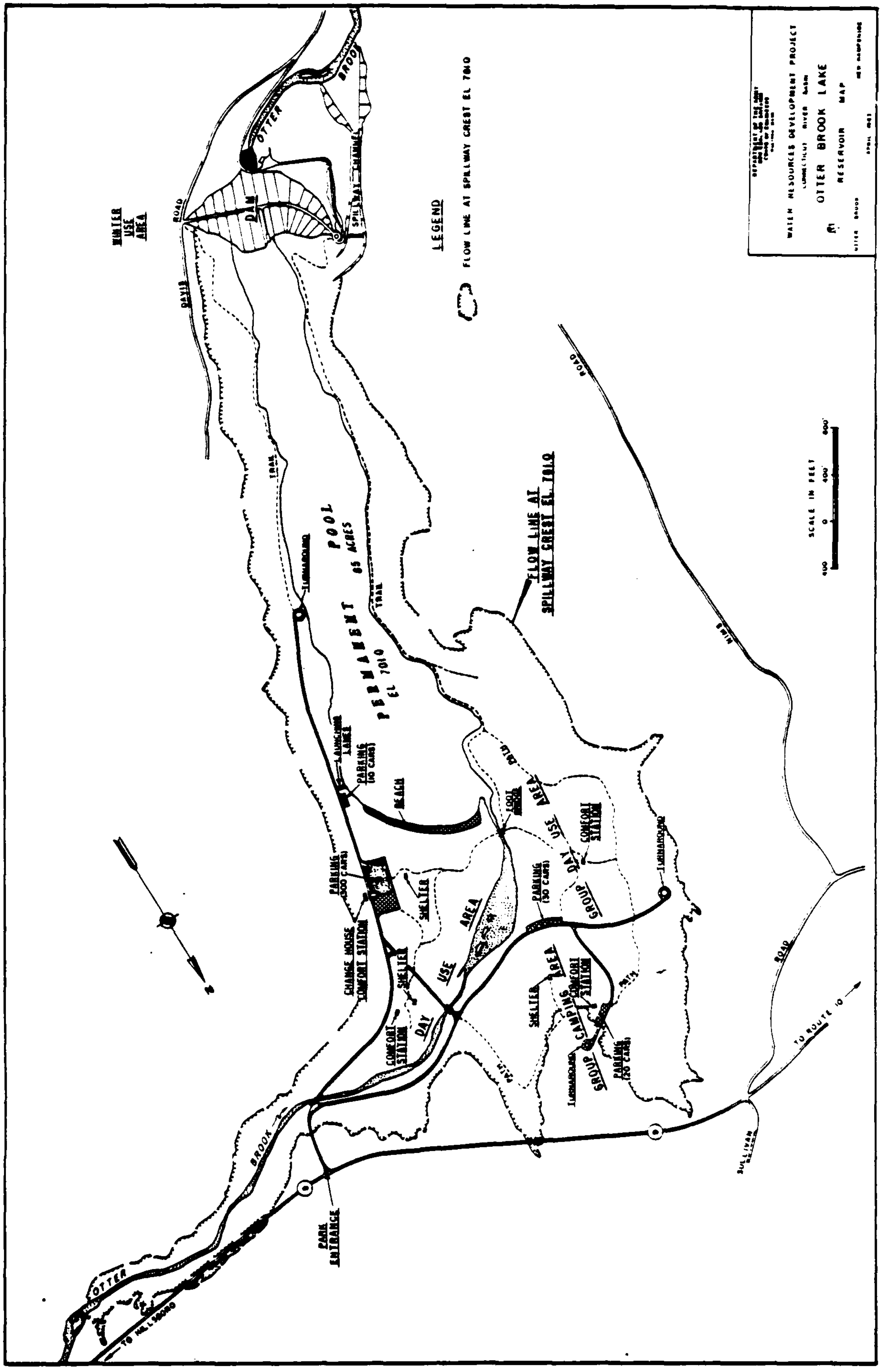

10-YEAR FREQUENCY
LOW FLOW ANALYSIS
NOTE:
RESERVOIR LEVEL
AT TOP OF PERMANENT
POOL AT BEGINNING
OF STORAGE
MAX. STORAGE - 2,040 AC-FT. ELEV. 715 FT.
665 MILLION GALLONS
POOL ELEVATION - 708 FT. - 1,300 AC-FT.
MINIMUM RELEASE - 0
MINIMUM RELEASE - 4.7 CFS (0.1 CSM)
TOP OF PERMANENT POOL - ELEV. 703 FT.
870 AC-FT
INFLOW (<4.7 CFS) = OUTFLOW
INVERT ELEV. 683 FT.
RESERVOIR STORAGE / INFLOW
VOLUME IN ACRE-FEET
DURATION IN DAYS
0
20
40
60
80
100
120
140
160
180
500
1000
1500
2000
2500
3000
CONNECTICUT RIVER BASIN
OTTER BROOK LAKE
DROUGHT CONTINGENCY
STORAGE VS. FLOW DURATION

PLATE 4



WATER RESOURCES DEVELOPMENT PROJECT
OTTER BROOK LAKE
RESERVOIR MAP
LEGEND
FLOW LINE AT SPILLWAY CREST
PERMANENT POOL
DAM
WINTER USE AREA
DAY USE AREA
GROUP DAY USE AREA
GROUP CAMPING AREA
BEACH
CHANGE HOUSE COMFORT STATION
COMFORT STATION
SHELTER
PARK ENTRANCE
SCALE IN FEET
TO ROUTE 10
OTTER BROOK

PLATE 5

DAT

ILM